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THE RELATIONSHIP BETWEEN TECHNOLOGY AND ORGANIZATIONAL STRUCTURES: EMPIRICAL TRUTH OR THEORETICIANS' WISHFUL THINKING?

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This research note reviews and analyzes the results of 34 empirical studies of technology-structure relationships. Previous reviewers have concluded that the across-study variation among sample correlations is attributable to differences in definition of technology, unit of analysis, and measurement strategy. These reviewers did not examine three theoretically important explanations for the mixed results: differences in 1) organizational size, 2) degree of professionalization, and 3) organizational sector. Meta-analyses indicate that these

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previously unexamined explanations are important for understanding the technology-structure relationship.

The Relationship Between Technology and Organizational Structure: Empirical Truth or Theoreticians' Wishful Thinking?

Many organization scientists and scholars emphasize the existence and importance of the relationship between technology and structure. Many others do not. This paper reports the use of meta-analysis to summarize the findings from 37 studies of these relationships.

There are four lines of reasoning that explain why technology and structure might be empirically correlated: (1) If a work unit's structure is poorly fitted to its technology, the resultant system will be less effective. For example, if decision-making authority is far removed from the work and if detailed rules and standard operating procedures are pervasive, the organization or subunit will tend to perform poorly if the tasks of its work units are unpredictable and non-routine. Managers, learning this from first or second hand experience, tend to avoid bad fits and create good fits. This might be called the experience argument. (2) Structure affects innovation. Changes in technology are innovations. Therefore, certain structures screen certain technologies (innovations) out or in, while other structures screen other technologies (innovations) out or in. The result over time is a pattern of pairings of structure and technology. This might be called the selective diffusion argument. (3) Uncertainty affects structure. At the work unit level, task uncertainty also affects technology. If both effects are strong, structure and technology will be empirically correlated even if not causally associated. This might be called the spurious correlation argument. (4) If certain structure-technology pairings are more efficacious than others, natural selection will cause them to become relatively more numerous and therefore observed more frequently. This might be called the population ecology argument.

Despite the appeal of these lines of reasoning, many organization theorists argue that technology and organizational structure are related only weakly, that other determinants of organizational structure are much more important. (Mohr, 1971; Child & Mansfield, 1972; Blau, Falbe, McKinley, & Tracy, 1976; Ballew, 1982). For example, the complexity and dynamism of the organization's environment are frequently noted as determinants of structure (Tung, 1979), and the preferences of organizational leaders as determinants of structure have recently received increased attention (Bourgeois, McAllister, and Mitchell, 1978; Allen, 1979; Bobbitt and Ford, 1980; Miller, Kets de Vries, and Toulouse, 1982).

A second and qualifying argument to the straightforward lines of reasoning noted above is that techno ogy and organizational structure are related in some contexts but not in others. For example, technology and structure are more likely to be related in effective, small organizations that are not dependent on a single, influential environmental actor. Effective organizations tend to adopt organizational structures congruent with their technologies, while ineffective organizations may survive with incompatible organizational structures and technologies. Similarly, organizational designers in small organizations have more latitude to adopt compatible technologies and structures than designers in large organizations (Hickson, Pugh, & Pheysey, 1969). Thus, the technology-structure relationship may be strong among small, but not large, organizations.

A final argument concerning the existence and generality of a technology-structure relationship is more methodological than theoretical. The methodological argument is that technology and structure may be related, but the existence or strength of the ρβσεθ×εϕ relationship is primarily a function of the methodology employed by organization researchers. Recent reviews note that the strength of the observed technology-structure relationship varies across studies because of the use of a avariety of measures, different levels of analysis, "institutional" and "subjective" methods, etc. (Ford & Slocum, 1977; Fry, 1982; Pennings, 1973; Reimann & Inzerilli, 1979; Sathe, 1978).

This string of arguments and counter-arguments outlines a long-standing debate in organization theory. The primary positions in the debate are that: (1) there is a strong technology-structure relationship, (2) structure is determined almost entirely by other factors, (3) technology may affect structure, depending on the level of moderator variables, and (4) the truth about the technology-structure relationship is unavailable from the empirical literature due to differences in research methodologies.

The purpose of this paper is to assess more thoroughly, or at least with a different methodology, the evidence concerning the following questions: Is there a technology-structure relationship? Under what conditions is this relationship stronger or weaker? What are the best methods for observing a technology-structure relationship?

The present paper has four advantages over previous reviews and examinations of the technology-structure relationship. First, it supplements traditional qualitative review techniques with quantitative meta-analytic techniques in order to provide estimates of the population level correlations between technology and specific dimensions of organizational structure and in order to assess more precisely the importance of substantive and measurement issues. Second, it addresses both substantive issues and methodological issues, rather than one or the other. Third, the study focuses on the three dimensions of structure which have received the most attention in the literature, centralization, formalization, and specialization. Fourth, although the technology-structure relationship has been subjected to extensive reviews (Ford & Slocum, 1977; Reimann and Inzerill, 1979; Gerwin, 1981; Fry, 1982), a large percentage of the empirical studies relating technology and structure have been published since the last major review and this review incorporates these new studies.

The conclusions of this paper should be interesting to all parties of the technology-structure debate, ranging from critics of contingency theories in organization science to practicing administrators. On the one hand, practitioner oriented journals and MBA textbooks currently give the impression that contingency theory notions have been empirically validated (e.g. Randolph, 1981; Daft, 1986). Contingency theory notions have been found to be pervasive in the mental models of organizations used by both practicing administrators and MBA students (Ford & Hegarty (1984). On the other hand, the empirical research is laden with weak and inconsistent empirical findings, causing Miner (1984) to conclude that contingency notions have low scientific validity and low practitioner usefulness.

Our summary of the technology-structure literature includes both a qualitative analysis of the issues and a quantitative meta-analysis of the empirical findings. The qualitative analysis considers the arguments and empirical evidence concerning substantive and methodological factors that may affect the existence or strength of observed relationships between technology and specific dimensions of structure and is a precursor to the meta-analysis. The meta-analysis parallels the qualitative analysis and attempts to address the questions left unanswered. The paper concludes with suggested directions for future research.

Qualitative Analysis

There are more than three dozen empirical studies of relationships between technology and dimensions of structure. Across these studies, bivariate technology-structure relationships have been found to be statistically significant in less than half of the cases. Further, many articles reviewing this literature have concluded that technology is related to organizational structure (e.g. Fry, 1982). Thus, to some, the case appears to be nearly closed. The field as a whole seems to have shifted from questioning the existence of a technology-structure relationship to examining the conditions affecting the strength of this relationship.

Substantive Factors Affecting the Technology-Structure Relationship

Organization scientists have posited several substantive factors that may affect the technology-structure relationship. In this section, we review the conceptual arguments and empirical evidence for five such factors. Three of these substantive factors, size, dependence, and performance, are the only substantive factors that have been empirically examined in more than one or a few studies. The remaining two, professionalization and line of work, are potentially important substantive factors that have received some conceptual attention, but very little empirical attention in the technology-structure literature.

Size. Organizational size is the substantive factor most associated with organizational structure in both conceptual and empirical studies. Large organizations enjoy economies of scale that encourage specialization of labor; which leads to forms of integration and coordination not required in smaller organizations, including on occasion formal rules and standardized procedures. In addition, top managers in large organizations face basic logistical problems in using direct interpersonal contact to coordinate large numbers of employees and subunits. This forces large organizations to decentralize.

Although size and technology may have independent, direct relationships with structure, size also potentially moderates the technology-structure relationship in two ways. First, size may have strong effects, such as those noted above, only among relatively large organizations. Among smaller organizations, size may not have such an overwhelming effect and the technology-structure relationship may be stronger.

Size may also affect the technology-structure relationship through its effect on homogeneity. Many organizational structure and technology constructs were developed in the context of workunits, departments, or homogeneous systems (Comstock & Scott, 1977; Perrow, 1967; Reimann, 1980). In very large organizations, the assumption of homogeneity may break down and make ambiguous the meaning of constructs such as formalization, specialization, and centralization. For example, a single statistical measure or nominal classification of an organization's technology may not provide an accurate description of the technology of a large organization engaged in multiple markets. Instead, separate descriptions for each work-unit would be required to describe the organization's technology. If these constructs of technology and organizational structure are only appropriate for smaller organizations, then the technology-structure relationship will be much stronger among smaller organizations than among very large and therefore heterogeneous organizations. Because the size of organizations that have been studied varies from an average of 20 employees in small, retail organizations (Paulson, 1980) to an average of 5150 employees in various manufacturing and service organizations (Hickson, Hinings, & McMillan, 1974), size may account for a significant amount of the variation in the strength of observed relationships between technology and dimensions of structure.

Dependence. The second most-researched factor affecting the technology-structure relationship is organizational dependence, the degree to which an organization or subunit relies upon external, concentrated forces for resources. Dependent organizations are frequently formalized and specialized in accord with their accountability to the strong environmental factors (Reimann, 1980). Dependent organizations also lack autonomy and may adopt an organizational structure that matches that of the external actor rather than their own technology.

The heightened accountability and decreased autonomy associated with high dependence encourages organizational leaders to design highly structured, bureaucratic organizations (Trostel & Nichols, 1982), that may be easily and quickly changed from the top down when the leaders feel pressure from a strong external force. In less dependent organizations, organizational leaders have more autonomy to structure their organization in accord with other contingencies, such as their technology. Decreased dependence, however, does not necessarily result in an unstructured, nonbureaucratic organization. Given the differences across studies in the average dependency of organizations and subunits, dependence may account for a significant amount of the variation in the strength of observed relationships between technology and dimensions of structure.

Performance. The primary structural contingency hypothesis is that the fit between technology and structure determines organizational performance. Unfortunately, most discussions of this hypothesis are restricted to theoretical papers and critical reviews (e.g. Reimann & Inzerilli, 1979). Few studies assess performance to test the hypothesis empirically (e.g. Hickson, Pugh, & Pheysey, 1969). The evidence from the published studies provides mixed support for the contingency hypothesis. This may be attributable to the extremely large sample sizes of 1,000+ required to test contingency hypotheses and the typically small sample sizes (20 to 200) actually obtained in organizational research.

If the structural contingency hypothesis is correct, the strength of the technology-structure relationship should be a function of the average performance level of sampled organizations. Where the average performance level is high, strong relationships should be found between technology and dimensions of structure. Given the differences across studies in the average performance of sampled organizations and subunits, performance may account for a significant amount of the variation in the strength of observed relationships between technology and dimensions of structure.

Professionalization. Professionalization can have a very strong direct effect on organizational structure (Hall, 1962; Scott, 1981). Organizations that employ large percentages of professionals remain low in formalization, centralization, and specialization for several reasons. First, professionals are highly trained with a variety of skills. When faced with uncertainty, organizations frequently hire professionals rather than develop complex rules or hire a variety of specialists. Second, professionals are socialized to maintain high performance standards without constant monitoring. Formalization and close supervision is less frequently necessary for professionals. Third, many professionals resist highly structured work settings and respond to these settings with low quality work and high turnover and absenteeism (Scott, 1981).

Professionalization could affect the technology-structure relationship by constraining the structure alternatives available in highly professionalized organizations. Under conditions of low professionalization, however, organization designers may be more sensitive to other factors such as technology. Professionalization may also be associated with the strength of the technology-structure relationship because professionalization tends to be positively related to the uncertainty or unpredictability of the technology. Organizations employing routine technology are unlikely to hire many professionals. Thus, there is a more limited range of technologies in highly professionalized organizations and this restriction of range may depress the strength of the technology-structure relationship.

Given the differences across studies in the average professionalization of organizations and subunits, professionalization may account for a significant amount of the variation in the strength of observed relationships between technology and dimensions of structure.

Line of Work. The strongest arguments against comparative organization studies are focused on comparing organizations from different lines of work, e.g., public vs. private sector, service vs. manufacturing, or different industrial sectors. The basic argument is that organization theories must be line of work specific. A prime example of this argument in the technology-structure literature centers on the differences between service and manufacturing industries. Of the 37 empirical studies in Table 1, only 7 studies include both service and manufacturing organizations. Many authors argue against comparing organizations across lines of work (Mills & Moberg, 1982).

Service and manufacturing organizations clearly differ in terms of outputs and core technologies (Cowell, 1980; Mills & Margulies, 1980; Mills & Moberg, 1982). Outputs in service organizations are often very intangible, inseparable into units, and unstorable compared to outputs of manufacturing organizations (Fuchs, 1969; Sabolo, 1975; Mills & Moberg, 1982). Mills and Moberg (1982) argued that these basic output differences lead to three secondary differences. First, service quality is judged primarily on subjective criteria without objective reference points. A second, and related, difference is that consumer relations are much more important to service producers because of their effect on consumers' subjective evaluations. Third, it is more difficult to implement quality control in service than in manufacturing contexts.

Service and manufacturing organizations also have very different core technologies. The core technologies in service organizations are typically located much closer to organizational boundaries than in manufacturing organizations. Thus, service organizations are less able to buffer their core technology units from external environmental variation (Mills & Moberg, 1982). Manufacturing organizations are better able to shield their technological cores from this source of uncertainty (Thompson, 1967; Mills & Moberg, 1982). The core technologies also tend to differ in process. Service organizations rely more heavily on "knowledge technologies" that require adept information processing coupled with intense interactions between service providers and consumers (Perrow, 1967; Thompson, 1967; Mills & Moberg, 1982).

These differences among lines of work are likely to affect the strength of the technology-structure relationship for several reasons. First, technology and line of work are highly associated. For example, manufacturing organizations are characterized by relatively high predictabilty and low uncertainty compared to service organizations. Second, there is probably much more variance in the predictability of work across service organizations than across manufacturing organizations because of greater proximity of service technology to the environment and greater variability in the routineness of knowledge technologies. The lower variance in manufacturing organizations would lead to a weaker technology-structure relationship. Given the differences across studies in lines of work included in samples, it seems that line of work may account for a significant amount of the variation in the strength of observed relationships between technology and dimensions of structure.

Other Factors. The five substantive factors discussed above may well affect the technology-structure relationship. Each of these five were discussed either because of the attention that they have received in the literature or, in the case of professionalization and line of work, because they could be used in the analysis. Other factors are also important, however.

Environmental dynamism and complexity, top management values, and top management goals are examples of other substantive factors that may affect the technology-structure relationship. When environments are dynamic and complex, and when top management values or goals are not congruent with the "natural" effect of technology (as when an autocratic top management team heads an organization doing unpredictable, non-routine work), technology and structure are not likely to be strongly related. Despite the theoretical importance of factors such as these, they remain uninvestigated.

In summary, there are several possible substantive factors that may explain variation in the results of technology-structure research. We tested the validity of three substantive factors as explanatory variables in the meta-analysis to be discussed subsequently.

Measurement Issues

Several prior literature reviews have emphasized measurement issues as accounting for the inconsistent results found in the technology-structure literature (e.g. Fry, 1982) Three factors have been discussed as the major causes of the inconsistent results found across technology- structure studies. Although other measurement factors exist, differences in conceptualizations of technology, levels of anlaysis, and sources of data have been cited as the cause of most of the inconsistent findings (Ford & Slocum, 1977; Reimann & Inzerilli, 1979; Fry, 1982).

It is important to remember that these factors, unlike the substantive factors, have nothing to do with **true** technology- structure relationships. Instead, these factors impact on **measured** relationships.

Construct Validity of Technology Measures. The use of different conceptualizations of technology is the factor cited most frequently as a cause of inconsistent technology-structure findings (Ford & Slocum, 1977; Reimman & Inzerill, 1979; Gerwin, 1981; Fry, 1982; Fry & Slocum, 1984). The conceptualizations of complexity (Woodward, 1965), operations technology (Pugh, Hickson, Hinings, & Turner, 1969), interdependence (Thompson, 1967), and routinization (Perrow, 1967) have generated more than six empirical technology-structure studies each.[1]

While it is generally agreed that the use of different variables has contributed to the inconsistency in observed relationships between technology and dimensions of structure, there is less agreement on how to interpret this inconsistency. On the one hand, complexity, operations technology, interdependence, and routinization, could be viewed as distinct constructs with independent relationships to organizational structure. If they are different constructs, however, then discussions of the technology-structure relationship must include explanations of why some technology constructs should be related more strongly to structure than other technology constructs. On the other hand, a more parsimonious alternative is to interpret them as divergent measures of a higher order technology construct (Fry, 1982). Fry noted that "Comstock and Scott (1977), Overton, Schneck, and Hazlett (1977), Galbraith (1977), Pfeffer (1978), Van de Ven and Ferry (1980), and Slocum and Sims (1980) imply that there is a higher level dimension of task predictability or uncertainty in technology in spite of the different theoretical definitions" in technology-structure research (1982: p.533). Thus, the more parsimonious, theoretically consistent, and popular interpretation of the technology literature is that complexity, operations technology, interdependnce, and routinization are different measures

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1. Several authors have identified six major technology conceptualizations (Fry, 1982; Fry and Slocum, 1984). In addition to the four cited above, operating variability (Pugh, Hickson, Hinings, and Turner, 1969) and manageability (Mohr, 1971) have been identified. Operating variability is not used here because it was conceptualized and operationalized not as a measure of technology, but as a measure of organizational charter. In addition, only two studies have employed it. Further, studies that Fry (1982) classified under the manageability conceptualization (2) were classified here under the routinization conceptualization. This was done due to the conceptual similarity of the two.

of technology rather than distinct dimensions of technology with independent relationships to organizational structure.

The observed inconsistency in relationships between technology and dimensions of structure might be explained as a problem of differences in the construct validity of the different measures of technology. For example, operations technology measures may have lower construct validity than the other measures. Because they focus narrowly on the rigidity of the workflow of the transformation process, operations technology measures probably capture only a small portion of the predictabilty or uncertainty inherent in technology (Kmetz, 1977/78; Reimann and Inzerilli, 1979). Support for this line of reasoning follows from Fry's (1982) finding that a "homogeneous body of technology-structure findings" began to appear after removing studies that used operations technology measures.

Complexity (Woodward, 1965) measures seem to capture a larger portion of the predictability or uncertainty inherent in technology. These measures focus on the type of procedures utilized in the transformation process, the number of units transformed by this process per time interval, the layout of work, and the type of customer order (Perrow, 1967). Complexity measures are broader measures of the predictability and uncertainty in the technology than operations technology.

Interdependence (Thompson, 1967) appears to be a second strong approach to measuring technology. Measures of interdependence seem to capture the predictabilty or uncertainty associated with input, transformation, and output workflow (Thompson, 1967).

The most popular and possibly the strongest measures of technology are based on routinization (Perrow, 1967), Because they capture the predictability or uncertainty associated with all phases of tasks and workflow, they may possess a broad base for claimimg construct validity.

Level of Analysis

The use of different levels of analysis is the second most discussed measurement issue in the technology-structure literature (Reimann and Inzerilli, 1979; Gerwin, 1981; Fry, 1982; Fry and Slocum, 1984). The use of organization, subunit, and individual levels of analysis across studies has often been cited as a source of inconsistencies in findings.

The most common criticism where level of analysis is concerned centers on organization level studies. Organization researchers frequently conduct their studies as if the organizations studied had one dominant, homogeneous technology and one dominant, homogeneous structure. Yet, high differentiation across subunits is evident in almost all organizations (Lawrence and Lorsch, 1967). The use of modal technology and structure measures results in this differentiation being ignored. The likely net outcome is that the observed variation in technology and structure variables is biased downward and the observed correlations between technology and structure dimensions are attenuated.

One implication of ignoring the differentiation across subunits in organization level studies is that studies utilizing the subunit level of analysis may exhibit relatively stronger relationships between technology and dimensions of structure, the stronger relationships derive from the increased variation on both technology and structure variables at this level. It also follows from this line of reasoning that relationships between technology and dimensions of structure would be strongest at the individual level of analysis. Given that subunits may also be differentiated, subunit level analyses also may miss variation on technology and structure variables.

On the other hand, there are at least two reasons why technology-structure studies conducted at the individual level of analysis might not exhibit the strongest relationships. First, often either technology or structure variables are not in reality measured at an individual level in "individual" level studies. Hrebiniak (1974), for example, used the interdependence of the subunit that an individual was located in as the individual's technology measure (as opposed to the interdependence associated directly with the individual's job). This measurement approach causes technology or structure variables to exhibit range restriction and relationships are consequently attenuated. Second, the aggregation of perceptual data, the predominant measurement approach in subunit level studies, can lead to aggregated correlations that are higher than the same disaggregated correlations (Hammond, 1973; Roberts, Hulin, and Rousseau, 1978). This aggregation bias could occur when there are level effects on the technology variable (i.e. when there is significant variation in the perceived values of technology and structure variables across individuals within given subunits).

For the reasons cited above, subunit level studies probably exhibit the strongest **measured** relationships between technology and dimensions of structure. Although the difference may be slight, it would also appear that individual level studies exhibit stronger **measured** relationships than do organization level studies. It should be emphasized that this discussion does not deal with true underlying relationships. It may well be that true relationships are stronger at the subunit level (because in reality differentiation exists across subunits but not within them), that is not the main point of this section, however.

Data Source Fit

The remaining measurement issue that has received a great deal of attention concerns how data is actually collected. On the one hand there are the "institutional methods", such as key informant interviews, analysis of archival materials, and on-site observation. Institutional methods are thought to provide data relevant to assessing formal organization (Pennings, 1973; Sathe, 1978). On the other hand are the "subjective methods", such as interviewing or administering questionnaires to a large percentage of organizational members. Subjective methods are thought to provide data relevant to perceived technology and structure, or informal organization (Pennings, 1973; Sathe, 1978).

The problem with having both of the above methods used across studies is that the methods are not necessarily convergent. Several authors suggest that convergent validity between institutional and subjective measures of organizational variables is low (Pennings, 1973; Sathe, 1978; Reimann and Inzerilli, 1979; Fry, 1982). Despite the possible lack of convergent validity, each measurement approach could be associated with strong **observed** relationships between technology and dimensions of structure; both approaches essentially entail researchers obtaining perceptions from organization members. However, if convergent validity between data collected using institutional methods and data collected using subjective methods is low, measures of association between structure and technology will be low due to the mixing of the uncorrelated formal and informal organization characteristics. Thus, when technology and structure data are not collected in the same manner across studies, the computed relationships between technology and dimensions of structure across these studies may be weak.

The above discussion has highlighted eight factors which possibly account for the variation in results across technology-structure studies. This is the point where most reviews stop. However, it is important that more precise estimates of the impact of these factors be made. It is to this task that the paper now turns.

Methods and Analysis

Overview

As indicated previously, a meta-analytic technique was used to estimate the population correlation between technology and centralization, technology and formalization, and technology and specialization. The impact of six of the eight substantive and measurement factors discussed above on relations between technology and dimensions of structure is also assessed.[2] The meta-analysis used to achieve these ends basically treats each empirical research study as a unit of analysis and, using data from the studies, integrates the findings among the variables of interest.

It should be emphasized that the term technology is defined in this paper as the predictabilty or uncertainty inherent in an organization's, subunit's, or individual's work. Readers should keep this definition in mind when examining the results of analyses.

Sample

37 empirical studies investigating the relationship between technology and one of the three key organizational structure dimensions were identified, collected, and perused. These studies were identified through the reference list of the most recent comprensive review of this literature (Fry, 1982), the **Social Science Citation Index**, an issue by issue search of **Academy of Management Journal**, **Academy of Management Review**, and **Administrative Science Quarterly**

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2. Unfortunately, only six of the factors discussed could be analyzed. Due to a lack of information in the published technology-structure studies, neither dependence nor performance could be analyzed.

for the years following the publication of the latest study cited by Fry (1982), and the reference lists of the articles found using the above methods.

Several studies cited by Fry (1982) were deemed inappropriate for this paper. First, Keller, Slocum, and Susman (1974) and Keller (1978) were not included. The decision to not include these two studies was based on the fact that they used the number of changes in technology over a five year period has their technology measure (Keller, Slocum, and Susman, 1974; Keller, 1978). Rousseau (1978) and others have argued that technological change is more closely aligned with the predictabilty inherent in organizational environments rather than the predictabilty inherent in an organizations day-to-day technology. Further, although Fry (1982) classified both of these studies as complexity studies, only continous process production organizations were investigated. Second, Rushing (1968) was not included in the analyses because his study is the only one in the technology-structure literature that used an industry level of analysis. Finally, data "associated" with the operations technology conceptualization were not used from the Reimann (1980) study. The use of computers in clerical functions was not taken to be a measure of operations technology as in Fry (1982). In addition to these selected omissions, because a common metric is required for the meta-analysis, only those 28 studies that reported bivariate correlations (or data which could be transformed into bivariate correlations) could be used in the analyses. Table 1 summarizes each of the 37 studies and the meta-analytic coding.

INSERT TABLE 1 ABOUT HERE

Data

Technology-Design Correlations. Correlations between technology and design characteristics were obtained from each of the studies. If there were multiple correlations for a given design variable, following Hunter, Schmidt, and Jackson (1982) a composite score correlation was computed where possible (16 of 24 cases).[3] If it was impossible to compute a composite score correlation, the multiple correlations were averaged. For example, if a study correlated routinization and two measures of centralization, a composite score correlation would be computed if possible; if not possible, the two correlations would be averaged. If a composite score correlation could not be computed and the correlation between the two or more measures of the structure variable deemed averaging inappropriate, face validity was used to select which measure (or measures) and which correlation (or correlations) to use. Table 2 reflects each correlation used in the analyses.

INSERT TABLE 2 ABOUT HERE

Several studies provided correlations between multiple technology conceptualizations and a given structure dimension. In order to assess whether or not the use of different technology conceptualizations accounted for any of the variation in results across technology-structure studies, correlations associ-

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3. A composite score correlation is given by the following equation:

$$r_{xy} = \bar{r}_{xy} / \sqrt{\bar{c}_{xx}}$$

where r is the average of the correlations between technology and each of the measures of a given design variable and $\bar{c}_{xx} = (1+(n-1)\bar{r}_{xx})/n$, where r_{xx} is the average inter-measure correlation and n is the number of indicators the structure variable has.

ated with each of the technology conceptualizations in these studies had to be used in the analyses.[4] This results in several correlations being non-independent, however. To determine the impact of this non-independence, the correlations were cumulated across studies in two ways.

The first method involved averaging the correlations between a structure dimension and the multiple technology conceptualizations within each study that used more than one conceptualization. If, for example, a given study reported correlations between complexity and formalization and between operations technology and formalization, these two correlations would be averaged. The resulting correlation would then be used in an analysis to estimate the population correlation between technology and formalization. The second method involved each correlation being treated as an independent observation. The population correlation between technology and formalization was then found using each available correlation. The differences found using these two approaches were slight. Each correlation was, therefore treated as an independent observation.

Size. The average number of employees within the organizations that a given study investigated was used as that study's organizational size measure. This measure of size was chosen because most of the studies reported this information and because the number of employees or a log transformation of the number of employees is the most popular measure of size in the technology-structure literature. It should be emphasized that average organization size was coded from the studies regardless of level of analysis.

Degree of Professionalization. The degree of professionalization that characterized a given study's sample was ascertained through an analysis of the

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4. Brass (1985), for example, used measures of both interdependence and routinization. In order to assess the moderating impact that the use of different technology conceptualizations has had on technology-structure relationships, correlations associated with both interdependence and routinization had to be used from the respective study.

text of each article. This analysis focused on whether or not the organizations or subunits within a given sample appeared to be predominantly characterized by jobs requiring specific, lengthy training. For most studies, it was a simple task to judge the degree of professionalization. Some authors commented directly about it. For example, Dewar and Werbel (1979) noted that unlike an Aiken and Hage study (1966), "few respondents had professional training." In other studies the degree of professionalization was inferred from the type of organizations or subunits being investigated. If nursing subunits (Leatt and Schenck, 1982) or subunits composed of social workers all of whom had B.A.'s and most of whom had M.A.'s in social work were used (Glisson, 1978), then it could be inferred that the degree of professionalization was relatively high. The first two authors of this paper dummy coded this variable (0 = low degree of professionalization, 1 = moderate to high degree of professionalization). Interrater agreement was high, 98% were rated the same.

Information on industrial sector, technology conceptualization, level of analysis, and data source fit were also obtained directly from the studies. In every case, the authors of the studies desribed their sample and research methods sufficiently so that the present authors could access the information required to set up dummy variables for each of these factors.

Analysis

A meta-analytic technique was used to estimate the population correlations between technology and the three key dimensions of organizational structure and to assess the impact of several substantive and measurement factors on those relationships. Meta-analysis refers to a collection of methods for cumulating and integrating research findings across individual studies. Although just becoming popular in the organization sciences, meta- analysis has been a research tool for quite some time in other social science fields (**The Academy of Management Journal**, **The Academy of Management Review**, and **Administrative Science Quarterly** have collectively published almost a dozen meta-analyses in the past two years, zero prior to that time period).

A simple meta-analytic method for estimating the population correlation coefficients between technology and each of the key structure dimensions involves the use of a weighted combination of population estimators from each study (Hunter, Schmidt, and Jackson, 1982; Hedges and Olkin, 1985). The simplest estimator available is the sample correlation coefficient. However, unless the sample size in each study is large ($n > 1000$), the z transformation (Fisher, 1921) of the sample correlation is a more acceptable estimator (Hedges and Olkin, 1985). Z transformed correlations not only are very close to being unbiased estimators (the sample correlation is surprisingly a **slightly** biased estimator), the transformation also approximately normalizes the sampling distribution of r. The approximate normalized sampling distribution allows hypotheses about the population correlation coefficient to be tested through confidence interval construction or significance testing (the hypothesis that $p = 0$ is being tested here). Z transformed correlations were used to estimate the population correlations in the study reported here.[5]

It is important to note that the estimator(s) from each study were weighted by that study's sample size (minus three) in order to take sampling error into account. The larger the sample size a given study uses, the more important are

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5. The z transformed correlation is given by the following equation:

$$z - z(r) = 1/2 * \log((1+r)/(1-r)).$$

The weighted average of z is given by:

$$z = w z + w z + \ldots w z,$$

where $w_i = (n_i - 3)/\sum_{j=1}^{K}(n_j - 3)$.

the findings of that study. This heightened importance is a function of sampling error; relatively smaller samples are more susceptible to the random distortions of this error source. Relatively larger samples provide correlations that are, on the average, closer to population parameters. Weighting the estimators results in the best estimate of the underlying population correlation coefficient (Glass, McGaw, and Smith, 1981; Hunter, Schmidt, and Jackson, 1982; Hedges and Olkin, 1985).

After estimating each technology-structure population correlation coefficient, the next step was to determine whether or not the variation across the sample correlation coefficients was entirely due to statistical artifacts. Statistical artifacts, particularly sampling error, often account for all of the sample correlation variance (Hunter, Schmidt, and Jackson, 1982). If statistical artifacts account for all of this variance across technology-structure studies, then the substantive and measurement factors discussed above do not play a practically significant role in relationships between technology and dimensions of structure. If statistical artifacts do not account for all of the variation, then the substantive and measurement factors may play a meaningful role.

There are several methods available for determining if the variation in the sample technology-structure correlations is attributable to statistical artifacts. All methods, however, basically use random effects models which assume that the population parameter being estimated across studies is not fixed. That is, that the population parameter behaves as if it has a sampling distribution and a variance of its own. If the assumed variance is in fact found to exist, then the variation in the sample correlations is not entirely caused by statistical artifacts.[6] Rather, a portion of the variation is caused by different population parameters existing in different contexts. For example, it may be that the underlying population correlation for the technology-centralization relationship varies by organization size. In studies that use large organizations, the population correlation being estimated may be .1, while in studies that use small organizations the population correlation being estimated may be +.6. Table 3 summarizes the estimated overall population correlations and variances.

INSERT TABLE 3 ABOUT HERE

If the sample correlation variance is not entirely accounted for by statistical artifacts, then the next step is to assess the impact of the substantive and measurement factors. A straightforward method for accomplishing this assessment involves the fitting of a general linear model to the correlations. In this paper, weighted least squares regression modeling was used to predict the transformed technology-design sample correlations. The z correlations were used in the regression modeling because regression modeling assumes criterion variables to be normally distributed; as mentioned earlier r's are not normally distributed (Hedges and Olkin, 1985). The substantive and measurement factors

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6. The variance of the population correlation is given by the following equation (Hunter, Schmidt, and Jackson, 1982):

$$\sigma^2(\rho) = \frac{\Sigma[N_i(r_i - \bar{r})^2]}{\Sigma N_i} - \frac{(1 - \bar{r}^2)^2 K}{N}$$

where N is a given study's sample size and K is the number of observations on r. This equation essentially corrects the variance of the sample correlations for sampling error. Other statistical artifacts generally play a very minor role in producing sample correlation variation. Sampling error was also the only statistical artifact that information was available on in the studies.

coded from each study were used as the predictors. Stepwise models were used so that the effects of multicollinearity were minimized.

Initially, due to degrees of freedom limitations, two separate regression models were fit to the correlations. One model used the substantive factors as predictor variables, the other used the measurement factors. Given that the substantive factors impact on true relationships (and measured relationships) and the measurement factors impact only on measured relationships, the results of these separate models should be theoretically meaningful. The significant predictors from each of the separate models were then used in an overall model. This trimming procedure results in somewhat overstated R^2's. Regression coefficients are also less stable than if an interative trimming procedure were used. Caution should, therefore, be used when interpreting the overall models.

The meta-analytic technique described above produces results with characteristics preferred over results obtained using chi-square analsis. Fry (1982), for example, used chi-square analysis to help determine if divergent technology conceptualizations, structure dimensions, levels of analysis, or sources of data influenced whether a study found statistically significant relationships or not. Such an approach has two undesirable consequences.

One of these, shared by most traditional literature reviews, rests with the emphasis placed on counting the number of statistically significant results. Generally, reviewers place great confidence in interpreting the meaning of knowing the number or proportion of studies that find statistically significant results. For example, Fry (1982) implied that the evidence for the existence of relationships between technology and dimensions of structure was weak because only 68 of 140 relationships were found to be significant. This reliance on vote-counting or box- score methodology can result in erronous conclusions because it discards information. For example, assume that the population correlation coefficient between technology and centralization is +.26. If researcher

A obtains a correlation of +.26 with a sample size of 30, he or she has not found a statistically significant result. On the other hand, if researcher B obtains a correlation of +.26 with a sample size of 45, he or she has found a statistically significant result. Although both researchers obtained sample correlation coefficients that were equal to the population coefficient, they will be treated very differently by reviewers who attend to significance tests--researcher A's study may be weighted "zero" while researcher B's study may be weighted "one". Thus bifurcated weighting, whether done explictly or subjectively, loses information not lost in meta-analysis.

The second problem that follows from this bifurcated weighting of results according to whether they were significant or not is related to sampling error. The utilization of small sample sizes ($n < 1000$) results in sampling error playing a major role in the results of studies. If K similiar studies each investigate a relationship with a non-zero population correlation coefficient, the probability of a significant result depends on the random effects of sampling error, in addition to sample size. For studies in the technology-structure literature, which tend to utilize small sample sizes and which investigate relationships that seem to have low to moderate population correlation coefficients, the probability of finding a significant result may be quite low.

Results and Discussion

Technology-Centralization

Technology and centralization were not strongly related across the 36 correlations reported in the 21 empirical studies examined. The estimated population correlation coefficient was +.137 ($p < .05$). However, the large variation at the population level ($\sigma^2 = .024$) indicated that the substantive and/or measurement factors may have been moderating the relationship.

Substantive Factors. 36 percent of the variation in the 36 sample correlations could be accounted for by the substanstive factors ($R = .60$, $p < .025$). The statistically significant regression coefficients were for size ($p < .005$), degree of professionalization ($p < .005$), and line of work ($p < .005$) Studies conducted in large organizations, studies conducted in organizations that had a great many professionals, and studies conducted in manufacturing organizations or subunits found weak technology-centralization relationships. Studies conducted in smaller organizations, studies conducted in organizations that do not have a great many professionals, and studies conducted in service organizations or subunits found stronger relationships.

Measurement Factors. The measurement factors could account for 39 percent of the variation in the 36 sample correlations ($R = .63$, $p < .005$). Only the data source fit regression coefficient was statistically significant ($p < .005$). Studies where data were collected from congruent sources found relatively stronger relationships.

Overall Regression Model. The overall regression model could account for 36 percent of the variation in the sample technology- centralization correlations ($R = .60$, $p < .025$). Sampling error accounted for another 23 percent of the variation. Thus, the majority (59%) of the variation in findings could be accounted for. With respect to the individual independent variables, each of the three substantive factors had statistically significant regression coefficients (each $p < .005$). The coefficient for data source fit was not significant.

The traditional organization theory notion that predictable, routine work brings about hierarchically concentrated authority was not supported, overall. In some contexts, however, the relationship was found to be stronger than in others. In particular, the meta-analysis indicated that the technology-centralization relationship is stronger in smaller, less professionalized, service organizations. The estimated population correlation for this context is +.36. The estimated population correlation for larger, more professionalized, manufacturing organizations is -.10.

It is interesting to note that the factors that have been focused upon as moderators in the technology-structure literature did not have a large impact on the technology-centralization relationship. The most discussed factor, technology conceptualization, did have some impact in that studies utilizing an operations technology conceptualization found somewhat smaller relationships. Beyond this, however, the measurement factors had little or no impact.

Technology-Formalization

Technology and formalization were moderately related across the 26 correlations in the 19 empirical studies examined. The estimated population correlation coefficient was +.363 ($p < .05$). As with technology-centralization sample correlations, the large variation at the population level ($\sigma^2 = .119$) indicated that the substantive and/or measurement factors may have been moderating the relationship.

Substantive Factors. 23 percent of the variance in the sample correlations could be accounted for by the substantive factors ($R = .48$, $p < .005$). Regression coefficients for degree of professionalization ($p < .005$) and industrial sector ($p < .005$) were statistically significant. Studies conducted in organizations or subunits which had a great many professionals, and studies which used manufacturing organizations or subunits did not find technology related positively to formalization. Studies conducted in organizations or subunits with few professionals, and studies which used service organizations or subunits found strong, positive technology-formalization relationships.

Measurement Factors. The measurement factors could account for 27 percent of the variation in technology- formalization correlations ($R = .51$, $p < .005$). Regression coefficients for both of the level of analysis dummy variables (individual level versus other, $p < .005$; organization level versus other, $p < .005$) and one of the technology dummy variables (interdependence versus other, $p < .05$) were statistically significant. Studies which used either an individual or organization level of analysis and studies which used the interdependence technology conceptualization did not find technology related positively to formalization.

Overall Regression Model. The overall model could account for 36 percent of the across study variation ($R = .60$, $p < .005$). When the variation due to sampling error was added to the variation that the model could account for, 44 percent of the total variation could be accounted for. Regression coefficients for degree of professionalization ($p < .005$), line of work ($p < .005$) and the interdependence dummy variable ($p < .005$) were each statistically significant.

Support for the traditional organization theory notion that predictable, routine work leads to substantial use of codified rules and standard operating procedures was found across all studies investigating such a relationship. The relationship was not, however, strong. Further, as with centralization, the meta-analysis indicated that the relationship between technology and formalization varies by context. In particular, technology-formalization relationships are stronger in less professionalized service organizations and subunits where technology is not conceptualized as interdependence. The estimated population correlation in the above context is +.70. The estimated population correlation for larger, more professionalized organizations where technology is seen in interdependence terms is -.36.

Technology-Specialization

Technology and specialization were not related across the 20 correlations reported in the 11 studies examined. The estimated population correlation coefficient was -.026 (n.s.). However, once again the large variation at the population level (σ^2 = .097) indicated that the substantive and/or measurement factors may have been moderating the relationship.

Substantive Factors. 59 percent of the variation in the sample correlations could be accounted for by the substantive factors (R = .77, $p < .005$). Regression coefficients for size ($p < .005$), degree of professionalization ($p < .005$), and line of work $p < .005$) were each statistically significant. Studies which used large organizations, studies which used organizations with a great many professionals, and studies which used manufacturing organizations found positive technology-specialization relationships. Studies which used smaller organizations, studies which used organizations which did not have a great many professionals, and studies which used service organizations found negative relationships.

Measurement Factors. The measurement factors were capable of accounting for seventy-five percent of the across study variation (R = .87, $p < .005$). Regression coefficients for two of the technology dummy variables (operations technology versus other, $p < .005$; complexity versus other, $p < .005$) and one of the level of analysis dummy variables (organization level versus other, $p < .05$) were statistically significant. Studies using operations technology and complexity conceptualizations found positive relationships while other conceptualizations yielded little relationship. Although the regression coefficient for the organization level of analysis versus other dummy variable was negative, the bivariate correlation between this dummy variable and technology-specialization correlations was positive. Further analysis revealed that the technology dummy variables forced the organization level dummy into the model with a negative coefficient. The technology variables appeared to be suppressing the actual effect of that variable.

Overall Regression Model. For the set of 20 correlations which examined the technology-specialization relationship, multicollinearity among the six factors which were significant in the separate models was prohibitively high. Using the six factors in an overall model resulted in predictor variables being forced into the overall model with signs reversed from bivariate signs and predicted correlations ranging from over +1.00 to below -1.00. Therefore, no overall model using each of the six factors is reported.

Conclusion

This analysis found that the commonly held belief that technology and structure are strongly related is incorrect. The best available estimates of the population level correlations between technology and the three key structure dimensions were found to be of low magnitude. Specifically, the results of our analyses suggest that the predictabilty or routineness of work does not greatly affect centralization, formalization, or specialization.

Relationships between technology and the three dimensions of structure were found to be strong, however, in certain contexts. Small, unprofessionalized, service organizations emerged as the context in which technology most strongly affects organizational structure. This finding supports those who have argued that technology and structure are weakly related in large organizations but not necessarly weakly related in small organizations.

The literature focuses on measurement factors as the cause of inconsistent findings across studies investigating the link between technology and structure. However, our analysis indicated that the most frequently discussed measurement factors (technology conceptualization, level of analysis, and source of data) do not have an overbearing effect.

The overall conclusion that follows from these findings is that neglecting the substantive factors which moderate relationships between technology and dimensions of structure and ignoring the possibility that different factors may moderate different relationships has resulted in a literature that is misleading.

The findings of this study contribute to understanding the relationships between technology and structure. However, there is still a great deal to be done. In particular, there is a need for further technology-structure research in at least four areas. First, substantive factors which could not be investigated here need to be empirically examined for their possible effects on relationships between technology and dimensions of structure. These include environmental dynamism and complexity and top management goals and values.

The second area where technology-structure research is needed concerns organizational performance. How important is the "fit" between technology and structure as a determinant of organizational performance? What pairings of technology and structure lead to high (or low) performance, and under what circumstances?

The third and perhaps most theoretically interesting need for technology-structure research follows from the field's ignorance of the reasons why technology and structure are related, to the extent that they are. Early in this paper we delineated four arguments explaining the existence of a relationship. Which explanations are valid under which conditions? Which are the domains where each of these theories are valid?

An important finding that followed from our review of the 37 studies is that although many of them discussed the results in causal terms, such as the "technological imperative", only a few of the studies were designed such that causality could be inferred. A fourth and perhaps most administratively important need is for causal direction-finding empirical studies. Without them we must remain extremely hesitant to advise organization designers. It seems that the time for longitudinal studies and key informant interviewing to ascertain causal sequences is long overdue.

Table 1

Summary of Study Characteristics and Coding

	Substantive Factors			Measurement Factors		
Author(s) (Year)	Organization Size	Degree of Professionalization	Industrial Sector	Technology Conceptualization	Level of Analysis	Measurement Congruence
Alexander & Randolph (1985)	----	low (0)	service	routinization (000)	subunit (00)	congruent (0)
Argote (1982)	----	high (1)	service	routinization (000)	subunit (00)	congruent (0)
Ballew (1982)	2081	high (1)	service	routinization (000)	subunit (00)	congruent (0)
Bell (1967)	----	low (0)	service	routinization (000)	Subunit (00)	congruent (0)
Blau et. al. (1976a)	497	low (0)	manufacturing	operations technology (010)	organization (10)	congruent (0)
Blau et. al. (1976b)	497	low (0)	manufacturing	complexity (100)	organization (10)	congruent (0)
Brass (1985)	180	low (0)	mixed (.25)[1]	routinization (000)	individual (01)	congruent (0)
Brass (1985)	180	low (0)	mixed (.25)	interdependence (001)	individual (01)	congruent (0)
Child & Mansfield (1972a)	1542	low (0)	mixed (.63)	operations technology (010)	organization (10)	congruent (0)
Child & Mansfield (1972b)	1554	low (0)	manufacturing	operations technology (010)	organization (10)	congruent (0)
Child & Mansfield (1972c)	1554	low (0)	manufacturing	complexity (100)	organization (10)	congruent (0)
Comstock & Scott (1977a)	----	high (1)	service	routinization (000)	subunit (00)	congruent (0)
Comstock & Scott (1977b)	----	high (1)	service	interdependence (001)	subunit (00)	incongruent (1)
Dewar & Hage (1978)	146	high (1)	service	routinization (000)	organization (10)	incongruent (1)
Dewar & Werbel (1979)	154	low (0)	service	routinization (000)	subunit (00)	congruent (0)
Fry & Slocum (1984a)	1295	low (0)	service	routinization (000)	subunit (00)	congruent (0)[2]
Fry & Slocum (1984b)	1295	low (0)	service	interdependence (001)	subunit (00)	congruent (0)[2]
Glisson (1978)	45	high (1)	service	routinization (000)	organization (10)	congruent (0)
Grimes & Klein (1973a)[3]	----	low (0)	manufacturing	routinization (000)	individual (01)	congruent (0)
Grimes & Klein (1973b)[3]	----	low (0)	manufacturing	routinization (000)	individual (01)	incongruent (1)
Grimes & Klein (1973c)[3]	----	low (0)	manufacturing	routinization (000)	individual (01)	incongruent (1)
Hage & Aiken (1969)	146	high (1)	service	routinization (000)	organization (10)	incongruent (1)
Harvey (1968)	799	low (0)	manufacturing	complexity (100)	organization (10)	congruent (0)
Hickson et. al. (1969a)	3370	low (0)	mixed (.67)	operations technology (010)	organization (10)	congruent (0)
Hickson et. al. (1969b)	3411	low (0)	manufacturing	operations technology (010)	organization (10)	congruent (0)
Hickson et. al. (1969c)	3411	low (0)	manufacturing	complexity (100)	organization (10)	congruent (0)
Hickson et. al (1974a)[3]	5150	low (0)	manufacturing	operations technology (010)	organization (10)	congruent (0)
Hickson et. al. (1974b)[3]	500	low (0)	manufacturing	operations technology (010)	organization (10)	congruent (0)

Hrebiniak (1974a)	350	high (1)	service	routinization (000)	individual (01)	congruent (0)
Hrebiniak (1974b)	350	high (1)	service	interdependence (001)	individual (01)	congruent (0)
Inkson et. al. (1970)	2000	low (0)	mixed (.60)	operations technology (010)	organization (10)	congruent (0)
Khandwalla (1974)	----	low (0)	manufacturing	complexity (100)	organization (10)	congruent (0)
Khandwalla (1977a)	----	low (0)	mixed (.63)	operations technology (010)	organization (10)	congruent (0)
Khandwalla (1977b)	----	low (0)	mixed (.63)	complexity (100)	organization (10)	congruent (0)
Kmetz (1377/1978)	----	low (0)	manufacturing	operations technology (010)	subunit (00)	congruent (0)
Leatt & Schneck (1982)	----	high (1)	service	routinization (000)	subunit (00)	congruent (0)
Mahoney & Frost (1974)	----	low (0)	mixed (.--)	interdependence (001)	subunit (00)	congruent (0)
Marsh & Mannari (1981a)	687	low (1)	manufacturing	operations technology (010)	organization (10)	congruent (0)
Marsh & Mannari (1981b)	687	low (1)	manufacturing	complexity (100)	organization (10)	congruent (0)
Negandhi & Reimann (1973)	1133	low (0)	manufacturing	complexity (100)	organization (10)	congruent (0)
Organ & Greene (1981)	----	high (1)	service	routinization (000)	subunit (00)	incongruent (1)
Paulson (1980)	20	low (0)	service	routinization (000)	organization (10)	congruent (0)
Reimann (1980)	1266	low (0)	manufacturing	complexity (100)	organization (10)	congruent (0)
Schoonhoven (1981)	----	high (1)	service	routinization (000)	subunit (00)	incongruent (1)
Sutton & Rousseau (1979)	150	low (0)	mixed (.07)	interdependence (001)	individual (01)	incongruent (1)
Tracy & Azumi (1976a)	1875	low (0)	manufacturing	operations technology (010)	organization (10)	congruent (0)
Tracy & Azumi (1976b)	1875	low (0)	manufacturing	routinization (000)	organization (10)	congruent (0)
Van de Ven & Delbecq (1974)	----	low (0)	service	routinization (000)	subunit (00)	incongruent (1)
Van de Ven et. al. (1976)	1250	low (0)	service	routinization (000)	subunit (00)	incongruent (1)
Van de Ven et. al. (1976)	1250	low (0)	service	interdependence (001)	subunit (00)	incongruent (1)
Woodward (1965)	542	low (0)	manufacturing	complexity (100)	organization (10)	congruent (0)
Zwerman (1970)	651	low (0)	manufacturing	complexity (100)	organization (10)	congruent (0)

NOTES:

1. Newspaper organizations are counted as 25% manufacturing. This applies to both the Brass (1985) and Child and Mansfield (1972) studies. Child and Mansfield (1972) and others have noted the hybrid nature of newspaper organizations.
2. There is a lack of congruence only for the specialization variable in the Fry and Slocum (1984) study.
3. Multiple samples were used by Grimes and Klein (1973) and by Hickson, Hinings, McMillian, and Schwitter (1974).

Table 2

Bivariate Correlations Between Technology and Design Variables

Author(s) (Year)	Centralization	Formalization	Task Specialization	Sample Size
Alexander & Randolph (1985)		-[1]		27
Argote (1982)	+.53			30
Ballew (1982)	NS	NS		196
Bell (1967)	+			30
Blau et. al. (1976a)			-.02	110
Blau et. al. (1976b)	+.27		+.03	110
Brass (1985)	+.50		-.36	140
Brass (1985)	+.47		-.40	140
Child & Mansfield (1972a)	+.17	+.30	+.41	82
Child & Mansfield (1972b)	+.04	+.16	+.18	40
Child & Mansfield (1972c)	+.23	-.26	-.22	40
Comstock & Scott (1977a)	-		+	99
Comstock & Scott (1977b)	+	+		99
Dewar & Hage (1978)			-.43	16
Dewar & Werbel (1979)	+.33	+.52		52
Fry & Slocum (1984a)		-.24[1]	+.30	61
Fry & Slocum (1984b)		-.07[1]	-.12	61
Glisson (1978)	+.10	+.22		30
Grimes & Klein (1973a)	+.11			828
Grimes & Klein (1973b)	+.12			928
Grimes & Klein (1973c)	+.08			180
Hage & Aiken (1969)	+.02	+.47	-.19	16
Harvey (1968)		+.75		43

Hickson et. al. (1969a)	-.30	+.34	+.41	46
Hickson et. al. (1969b)	+.11	+.41	+.43	31
Hickson et. al. (1969c)	.00	+.17	+.22	31
Hickson et. al. (1974a)	-.27	+.33	+.42	21
Hickson et. al. (1974b)	+.17	+.10	+.13	24
Hrebiniak (1974a)	+.13	+.05		174
Hrebiniak (1974b)	+.21	+.14		174
Inkson et. al. (1970)	-.39	+.51		40
Khandwalla (1974)	+.11	+.08[1]		79
Khandwalla (1977a)	-.28			103
Khandwalla (1977b)	-.21			103
Kmetz (1977/1978)	NS	NS		74
Leatt & Schneck (1982)	+.03	+.08		148
Mahoney & Frost (1974)	NS			297
Marsh & Mannari (1981a)	+.01	+.46	+.07	50
Marsh & Mannari (1981b)	+.03	+.33	+.19	50
Negandhi & Reimann (1973)	-.14			30
Organ & Greene (1981)		+.61		89
Paulson (1980)			-.39	77
Reimann (1980)	+.47	+.47	-.04	19
Schoonhoven (1981)	+.12	+.29		17
Sutton & Rousseau (1979)	+.16	+.12[1]		155
Tracy & Azumi (1976a)		-.03		44
Tracy & Azumi (1976a)		-.07		44
Van de Ven & Delbecq (1974)		+.88		120
Van de Ven et. al. (1976a)	+.35	+.49		197

Van de Ven et. al. (1976b)	+.20	+.26	197
Woodward (1965)	a[2]		81
Zwerman (1970)	a[2]		55

NOTES:

1. Alexander and Randolph (1985), Fry and Slocum (1984), Khandwalla (1974), and Sutton and Rousseau (1979) included a surveillence component in their formalization measures and were not inciuded in the formalization analyses.
2. Woodward (1965) and Zwerman (1970) found convex curvilinear relationships.

GENERAL NOTE:
For studies where correlations were unavailable, a "+", "-", or "NS" is used to denote what was found.

Table 3

Population Parameter Estimation

		A	B	C
estimated population correlation	=	+.137	+.363	-.026
variance of sample correlations	=	.031	.130	.097
sampling error variance	=	.007	.011	.018
population correlation variance	=	.024	.119	.079
population standard deviation	=	.155	.345	.282
number of correlations	=	32	26	20
number of observations	=	4216	1765	1135

NOTE:

A = Technology-Centralization
B = Technology-Formalization
C = Technology-Specialization

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